QIOPTIQ
Photonics for Innovation

OPTOLINES

JOURNAL FOR PHOTONIC SOLUTIONS

Gold coating: New technique
Excellent product and environmental properties

Shear Plate Interferometer
Laser beam collimation testing –
reliable results in seconds

Qioptiq at Photonics West
11 pages abuzz innovate Qioptiq products

Special edition

Visit us at
South Hall | Booth 1515

SPIE Photonics West

inspec.x L lenses enable high-resolution
line application for the first time

Editorial

Dear Readers,

Photonics West, the flagship event for the Photonics, BioPhotonics and Laser Industry in North America, is fast approaching. Attendees will meet and interact with photonic and optical experts from all over the world. In all, more than 19,000 visitors are expected in San Francisco for the exhibition in 2012!

At the Qioptiq booth we invite you to make use of the direct and personal contact with some of our brightest technical minds, product experts and global sales team. They will show you a wide range of recent Qioptiq innovative products and solutions which will contribute to strengthening your market position.

In this edition of OPTOLINES, please find informative briefs on our new products and innovations. In detailed background articles you can learn a lot about the features and advantages of our product highlights. Or you may visit our online shop at www.qioptiq-shop.com.

North America and Asia are both markets of great importance for us and for the photonics industry as well. Qioptiq is strengthening its presence in the US and Singapore with aims to expand our business in these key regions. We are now broadening our customer service and improving our logistics for catalog products with broadening regional inventories. We are expanding our advanced photonic manufacturing and technology integration capabilities with state-of-the-art clean room facilities, expanded ISO 13485 certifications and ultra-precise validation systems to ensure unmatched quality and consistency.

In San Francisco, you will be amongst the first to discover our NEW 2012/2013 catalog. 860 pages detail more than 4,800 products and application solutions... Innovation awaits you in San Francisco. See you at Photonics West!

David Marks
CEO

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Experience Qioptiq booth 1515 and launch your innovation!

The 2012 Qioptiq booth at SPIE Photonics West is loaded with new and innovative demonstrations and product displays serving a wide range of markets and applications.

Medical & Life Sciences

- Automated Microscopy System
- Photonics Engine Imaging System
- Fiber-delivered Laser Technology
- Micro Optics and Assemblies
- X-Ray Optics
- World's Smallest Endoscopic Camera... 1.2mm O.D.!
- Fiber-Delivered Laser Technology
- Electro- and Magneto Optic Modules for Laser Surgery
- Inspec.x D Liquid Lens Dental Camera Wand

Industrial Manufacturing

- Dual-Magnification Inspection Station
- Inspec.x Scan In-situ Laser Control System
- Motorized Beam Expander
- Linescan Lens with High-mag Beam Splitter Accessory
- Single-Objective Probing Microscope
- High-Resolution Machine Vision Lens
- Power Ronar F-Theta Len
- Micro-Inspection Lenses

Research & Development

- USB Spectrometer Color Detection System
- Precision LINOS Bench mechanics
- The all NEW 2012 LINOS product catalog and online Q-Shop
- Optotune Electronically Focusable Variable Lens
- Qioptiq Optical fabrication and Coatings samples
- Varioptic Liquid Lens Technology
- Compact Nano Diode Laser Systems

Take Home Your Free Q Stunt Kite!

Three Fun ways to win...

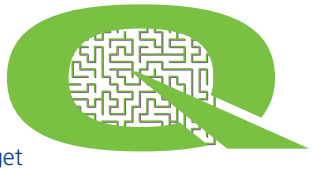
1) UNTIE THE FLEXIBLE LASER KNOT

Visually trace three Qioptiq iFLEX Laser Sources through more than 30-meters of twisted and braided fiber to identify the correct output

2) WHAT'RE YOU LOOKING AT ?!?!

Keep up with the lightning fast optical zoom of the Fetura lens System as you try to guess the abstract microscope specimen in only three multi-magnification glimpses

3) NAVIGATE THE QIOPTIQ LASER MAZE



Manipulate a maze of LINOS automated bench mechanics to steer three laser sources to the designated target

Launch Your Innovation

Come in to the all new ***Qioptiq Innovation Launch Pad*** at Photonics West and challenge our brightest minds with your most perplexing photonic application... Optics, lasers, optomechanics, controls, integration... Qioptiq has your solution.

Submit your challenge to the Innovation Launch Pad for your chance to WIN an iPad 2

QIOPTIQ Photonics for Innovation

Innovate to New Heights!

Magneto-optics and electro-optics

High quality products from Qioptiq

The combination of our years of experience, intelligent design and sophisticated engineering with computer simulations and complicated processing produces the enduring high quality of our products for magneto-optics and electro-optics. The product spectrum ranges from Faraday isolators to laser modulators to Pockels cells, and includes both standard and customized solutions.

Phase modulator PM-C-BB

Our laser modulators for applications outside the laser cavity are available for a broad wavelength range. Outstanding features of the new model PM-C-BB phase modulator include its compact design and an economical price. It is specially designed for applications in metrology and interferometry. Thanks to its electro-optic crystal, cut at Brewster's angle, it is just as well suited for a broad wavelength range within in the laser cavity. For the best phase stability, we also offer a version with integrated temperature stabilization. A one-inch mounting adapter facilitates mounting, for example in a one-inch Lees or adjust.x mirror mount.

Phase modulator PM-C-BB.

Pockels cells

The Pockels cells give you a large selection of crystal materials for wavelengths from 250 nm to 3 µm. Our BPC 8, with its KD*P crystal cut at Brewster's angle, enables very high transmission and is excellently suited for lasers with low amplification.

Pockels cells.

Faraday isolator

A highlight of the Faraday isolators is the addition of the FI-488-3SC and -5SC models to our extremely compact SC Series. The use of optically contacted polarizers ensures the high isolation and transmission of this model. Our SV Series has been expanded by the addition of model FI-405-5SV, a single-stage isolator that is exceptional not only for its excellent optical values but also for its cylindrical design and small dimensions.

Faraday isolator.

See Live Demo! BOOTH 1515

Motorized Color Detection Set

with Qwave spectrometer

At Photonics West 2012 Qioptiq presents the "Motorized Color Detection Set". This set is a functional setup with our new Qwave spectrometer and an x.act Linear Positioner to perform an automized color detection experiment. Different color probes are placed automatically in front of the Qwave spectrometer. The different color spectra are displayed on a computer monitor. The setup is illiuminated by a LED-Gooseneck light source.

These semi-rigid light guides provide direct illumination of the object. This is the ideal lighting technique for objects with matt finish or slightly reflective surfaces.

Professional LED gooseneck reflected light lamps of Qioptiq's SL series are specially designed for use in science and industry. State-of-the-art LED technology makes this product a professional, efficient, environment-friendly and, above all, economical alternative to conventional halogen lamp systems with a glass fiber gooseneck. The light output can be steplessly adjusted.

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Spectrometer for all applications

Compact USB spectrometer: Exceptional specifications

Hardly bigger than a deck of cards: The new Qwave spectrometer.

In a housing hardly bigger than a deck of cards, the new Qwave spectrometer achieves high resolution, sensitivity and stability, making it ideal as a universal spectrometer for a variety of applications. The spectrometer is controlled and its data downloaded using a PC, with operating software that is unique throughout the world for its user-friendliness and high performance.

With a focal length of 75 mm, the Qwave attains specifications normally seen only in much larger spectrometers. In the standard version, it offers a resolution of 0.5 nm and covers a wide spectral range from 350 nm to 950 nm. The range can be configured anywhere between 200 nm and 1100 nm to meet customer requirements. The narrower the spectral range, the higher the resolution.
Furthermore, the instrument is distinguished by high sensitivity, a signal-to-noise ratio of 2000:1 (at 1 second exposure time) and excellent thermal stability in a temperature range from -15 to +60 °C.

Unique software

The spectrometer is controlled using the "Waves" program, included in delivery, which not only uses advanced algorithms for measurement and evaluation, but also makes these functions easily accessible in its clearly laid out, intuitive user interface.

Many of the measurement and analysis features are available at a single mouse-click. With Qwave, the dark spectra for optimum sensitivity no longer have to be recorded anew every time the exposure time is changed. Instead, a number of automatically recorded dark spectra are stored as calibration values and interpolated. In conjunction with the automatic lighting control and the calibration of the wavelengths and spectral sensitivity, a single mouse-click is all that is needed to record a spectrum with the highest possible accuracy. Furthermore, several spectra can be recorded, displayed and compared. The strip chart function enables graphic display of a variety of characteristics of these spectra, which can be very useful for analyzing transients, for example. The complete software package, including drivers and updates, is included in delivery of the spectrometer.

Software features

- Import spectra as ASCII files
- Export spectra as ASCII files for further evaluation with Origin, Excel or other programs
- Calculation of statistical values
- Print the diagrams and export them as PDFs
- Dynamic peak finder (no threshold setting necessary)
- Automatic wavelength calibration
- Colorimetry
- Software developers' kit for customizing the spectrometer control program

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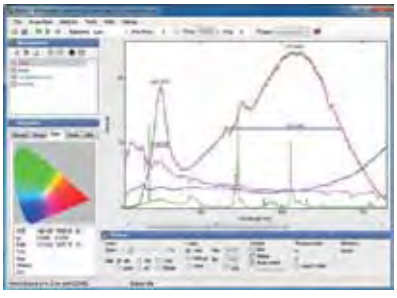


The complete "Waves" software suite is included in delivery.

QIOPTIQ Photonics for Innovation

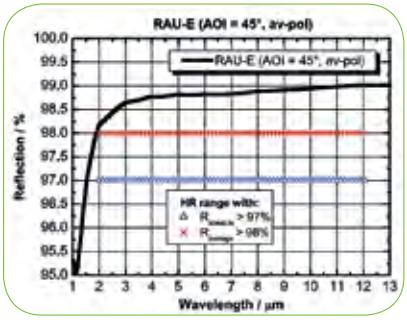
Innovate to New Heights!

Scratch-resistant mirror with gold surface

Newly-developed metal coating with dielectric protective layer

In the LINOS catalog from Qioptiq you will now find the new gold surface mirror for the infrared spectral range up to 25 µm. This mirror series is characterized by greatly improved resistance to environmental influences: abrasion-proof, high reflection, climatically stable and highly adhesive. Round mirrors with diameters of 12.7 mm, 25 mm and 50 mm, and an elliptical mirror with principal axes 22.4 mm x 31.5 mm, can be delivered ex-works at attractive prices. The gold layer on these mirrors is protected by a newly-developed dielectric coating. This ensures that the mirrors are scratch proof pursuant to MIL-M-13508C 4.4.5. Resistant to solvents pursuant to MIL-F48616, 4.6.9.2 they are easier to clean and are also resistant to moist heat (MIL-C-48497, 4.4.6). Nevertheless, they guarantee a high degree of reflectivity in the IR spectral region over a wide angle of incidence range without absorption band: average value of the reflection average >98% over 2 µm for an angle of incidence range of 0° ≤ AOI ≤ 60° (unpolarized) (Fig. 2).

Gold mirror for the infrared spectral region of up to 25 µm.



High reflectivity in the IR spectral region over a wide angle of incidence range without absorption band.

Order No.	Dimensions of gold surface mirror
G340 575 000	Ø 12.7 mm
G340 576 000	Ø 25.0 mm
G340 577 000	Ø 50.0 mm
G340 578 000	Ø 22.4 mm x Ø 31.5 mm

New microscope lenses

Now in the LINOS catalog range: high-quality, low price

New in the LINOS catalog from Qioptiq is a series of four high-quality, low-price light reflector lenses with magnifications between 5x and 50x. These lenses are constructed without cover glass correction. They are likewise excellently suited to laser beam broadening.

Magnifications between 5x and 50x – new microscope lenses.

The parfocal length, i.e. the distance between the mounting surface of the lens and the object plane, is 45 mm. The lenses have an RMS thread (W 0.8" × 1/36") and are achromatically corrected.

Article No.	Enlargement	NA	Focal length	Working clearance
G038 770 000	5x	0.10	40	18
G038 771 000	10x	0.25	20	5.9
G038 772 000	20x	0.40	10	1.8
G038 773 000	50x	0.65	4	0.4

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Qioptiq presents a new series of the time-tested MeVis lenses:

MeVis-CF - Highest imaging performance in a compact, rugged housing

Qioptiq has offered the MeVis-C lenses for the widely used C-mount cameras with sensor sizes of up to 1" for many years. Especially for today's high-resolution sensors, MeVis-C lenses are the ideal match. With exceptionally high resolution over the entire image circle, low distortion and good color correction, as well as low brightness drop, MeVis-C enables solutions for sophisticated image processing tasks.

Building on the MeVis-C series, Qioptiq has now developed MeVis-CF lenses featuring the long-established optics in an even more compact housing, to meet the most rigorous requirements. With this new series, Qioptiq supports applications that call for maximum image quality in a compact and rugged housing. Their optical data is identical with that of the proven MeVis-C series. Moreover, the fixed aperture means the lens takes up the least possible space while preventing operator error. These lenses are available in a number of variants with different apertures, making it possible to offer customer-specific versions with special aperture shapes.

- Highest imaging performance
- Compact and rugged housing
- C-mount with up to 1" sensor size
- Available focal lengths: 16, 25, 35 and 50 mm

Qioptiq expands inspec.x L series:

inspec.x L 4/105 now in use with prism module

In high-resolution applications, each individual component is essential while at the same time, the interaction of all components is crucial. Qioptiq offers lenses for line applications that come prepared for use with beam splitters in coaxial bright-field illumination, as well as the corresponding beam-splitter module, to enable the use of coaxial reflected light in high-res applications.

At high resolutions in the range of 5 µm and lower in combination with optical magnifications > 1, a beam splitter prism is the best option for creating functional coaxial illumination. Because the accuracy of the prism and its positioning in the beam path are subject to very stringent requirements, Qioptiq has developed a prism module that is ideally suited for use with inspec.x L lenses. It is easy to mount on the objective and also offers azimuthal alignment.

This prism module features the high industrial quality that is standard at Qioptiq. Moreover, it is optimized for the use of light guides and equipped with a universal interface that enables connection of any commercial line illumination with the corresponding adapter.

Initial use at customer locations has shown outstanding test results both for the imaging quality of the overall system and for ease of operation. All in all, this is an excellent example of German engineering in precision optics.

This module can be used in scanning applications at resolutions that up to now were the exclusive realm of microscopes.

- Magnification: 3.0x, 3.5x and 5.0x
- Diffraction-limited
- Coaxial illumination
- Optimum color correction
- Universal mounting system

QIOPTIQ Photonics for Innovation

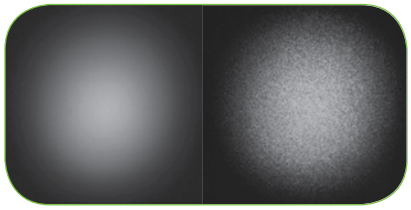
Innovate to New Heights!

Laser speckle reducer

New addition to the LSR-3000 series from Optotune

New laser speckle reducer.

The speckle noise of a laser system is reduced by dynamic scattering of the laser. An electroactive polymer membrane is controlled by two electric signals and moves a central diffusor in both the x- and y-direction. The new speckle reducers of the LSR-3000 series from Optotune have certified drive electronics and are supplied by a single micro USB connection. LSR-3000 is available in two versions with a free aperture of 5 mm or 10 mm and different scattering angles.



CCD image of a laser spot with LSR-3005 switched on and off respectively.

Article No.	Wavelength range (nm)	Scattering angle (°)	Free aperture (mm)
G399 557 000	400 - 700	1	5
G399 558 000	400 – 700	10	5
G399 559 000	400 – 700	20	5
G399 560 000	700 – 1100	1	5
G399 561 000	700 – 1100	10	5
G399 562 000	700 – 1100	20	5
G399 563 000	400 – 700	1	10
G399 564 000	400 – 700	10	10
G399 565 000	400 – 700	20	10

Laser Modules Series NANO 100

Light sources for LINOS Nanobench

The new laser modules in the NANO 100 Series from Qioptiq correspond to the NANO 250 Series laser modules, which are compatible with the LINOS Microbench. The dimensions of this new, extremely miniaturized system are adapted to the smaller LINOS Nanobench system. The housing, while measuring only 25 x 25 x 40 mm, contains not only the laser diode with collimation optics but also the controller. The maximum output power is up to 100 mW. No additional power supply unit is necessary because the module is powered over a USB connection. The USB port also provides a computer interface for monitoring and manipulating the operating parameters of the laser modules, which come with the NANO Control software for Windows. All the commands for programming the interface are described in detail in the user manual, so you can control the laser modules through your own programs.

- Beam Diameter: 1.1 x 2.2 to 1.2 x 2.8 mm (0.043 x 0.087 to 0.047 x 0.11 in.), depending on wavelength
- Divergence: < 0.9 mrad
- Spatial Beam: TEM00
- Polarization: linear, > 100:1

- Polarization Angle: vertical ± 5° (cage mounting allows simple rotation for horizontal polarization)
- Beam Alignment: < 5 mrad and < 0.1 mm (compared to base mount)
- Pointing Stability: < 5 µrad/K
- Noise: < 1 % RMS
- Power Stability: < 1 % (10 h)
- Dimensions: 40 x 25 x 25 mm (1.57 x 0.98 x 0.98 in)

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NEW: Motorized Beam Expander with variable magnification 2x to 8x

Fast, precise, compact

By setting the expansion factor and the divergence of the beam expander optics it is possible to vary the spot size and the plane of focus position.

Drive System and Controller

The drive system of the motorized beam expander consists of two independent stepper motors. The software concept of the controller is based on LabView. All major data, including the offset values, wavelength, serial number, parameter settings, are stored in a permanent memory within the controller.

Optical Design

The design of this motorized beam expander is based on the vast experience of the well known manual LINOS beam expanders 2x-8x for 355 nm, 532 nm and 1064nm. Additionally models with fused silica lenses for 355 nm, 532 nm and 1064 nm now complete the series.
The wave front error for all different types and magnifications is better than 0.03 RMS. All motorized beam expanders are diffraction limited.

Benefits

- Continuous variable magnification 2x ... 8x
- Wavelength 340-355 nm, 515-540 nm or 1030-1080 nm
- Fused silica or optical glass
- Expansion and divergence adjustable
- Software running on Windows® platform
- Reduced machine setup times by automatic change of magnification
- Laser protection class remains during readjustment of the beam expander
- All-in-one design, controller integrated
- ICE conform, IP 40

Technical Data

- Entrance beam diameter: max. 8 mm
- Exit beam diameter: max. 31 mm
- 10 individual pre-sets for magnification and divergence
- Pointing stability < 0.5 mrad
- Fast adjustment from 2x to 8x within 5 sec
- Mechanical interface via high precision holes 6 H7 or mounting diameter 39 h11
- Different electronic interfaces: SubD9; USB 2.0; Phoenix Contact
- Baud rate: 57600 bit/sec
- Power input 7–12 V, Phoenix Contact 7-24 V

QIOPTIQ Photonics for Innovation

Innovate to New Heights!

DAGIR on the right Path

Uncooled Thermal Image Surveillance system moves into gear

DAGIR, the Qioptiq surveillance system, utilizes state-of-the-art, low power uncooled IR camera technology to provide a flexible solution to mobile surveillance requirements.

DAGIR has been taken on the road (literally). Its IR camera technology and modular construction proves a winning combination either mounted in a fixed location or on a vehicle to provide border and coastal surveillance, homeland security, infrastructure protection or force protection.

DAGIR flexibility allows the user to add a number of optional items including; colour day camera, GPS, digital magnetic compass or laser range finder making it ideal for differing counter terrorism requirements when integrated into marine and land platforms.

DAGIR mounted on Jordan Panther Multi-Roll RSTA System.

DAGIR mounted for observation in extreme conditions.

DAGIR capitalizes on Qioptiq's experience in fielding uncooled thermal imagers in dismounted close combat areas.

They are cost effective surveillance cameras with the reliability of uncooled detectors ideal for System Integrators and forward observation units addressing the needs of a low power environment.

The design allows Infra-Red detector configuration with a variety of optional detector solutions available. A built-in growth path allows DAGIR to be future proof, giving customers the opportunity to upgrade performance or configuration.

For further information visit:
www.qioptiq.com

NANO 250 laser modules: Precise control

New remote control unit

The new RemoteControl unit offers users all of the functionality found in the familiar NanoControl software – and makes it accessible without the computer. This unit is simply connected to the laser controller using the micro-USB cable that comes with the laser system. Power is supplied to the unit over the USB cable. The RemoteControl has a 5-button pad for operating the laser modules, as well as a 3-line display.

Laser diode temperature control

The RemoteControl can be used to switch the laser on and off, as well as to adjust and display the laser output level. Furthermore, this remote control unit offers the unique option of influencing the wavelength by adjusting the laser diode temperature (shift of up to ± 5 nm). The temperature can also be viewed on the display.

Features: Focus on RemoteControl

- 5-button operating pad
- 3-line display
- Contrast and brightness can be adjusted separately
- Powered by the laser controller; no separate power supply for the remote control
- Simple connection to the laser system using micro-USB cable (included with the laser system)
- Display and adjustment of laser temperature (if this function is supported by the laser system)
- Display and adjustment of laser output power
- On/off switch for laser operation
- Displays operating status of both key switch and interlock input

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Discover the Qioptiq World!

Global presence, far reaching capability

Defense & Aerospace: learn more about our modules, technology and equipment for defense and aerospace applications

Defense modules

Qioptiq is a leading manufacturer of optics and optical modules for infrared detection, warning and imaging systems. Our infrared systems components are used in equipment designed to detect and track any kind of thermal targets, including missiles, tanks, armored vehicles, helicopters and fighters, for situational awareness or to detect threats related to thermal light emission. Our expertise also has commercial applications and is used, for example, in lenses for thermal inspection systems.

Qioptiq is renowned for the design and manufacture of visible light optical components for a wide-range of avionic, hand-held and vehicle-based platforms. Using state-of-the-art technology, Qioptiq has facilities for the volume manufacture of visible components around the world, giving us the ability to satisfy requirements for all applications, civil and military.

Qioptiq has been a leading manufacturer of UV components and imaging optics for many years. Qioptiq develops and produces ultraviolet and solar blind imaging systems for both defense and commercial applications, such as imaging and warning systems to detect and track short and long-range missiles, gunfire or threats related to any kind of UVC light emission.

Leading the world in technology and facilities, Qioptiq provides solutions to meet the individual requirements of defense customers. The Qioptiq product range covers the complete spectrum of requirements for electro-optical modules and complex optical components for Airborne, Land and Naval applications. We are a recognized, first-tier supplier of many of the world's leading defense companies.

Holography

The holographic department at Qioptiq UK, St Asaph, North Wales is regarded as one of the world's leading production facilities for the design and manufacture of Holographic Optical Elements (HOEs). It is one of only a few that has successfully manufactured HOEs for avionic display applications, in volume. The facility has been in full scale operation for almost 30 years producing over 6000 holographic elements.

Qioptiq has an international reputation for the design and manufacture of optical modules for Head-Up, Head-Level, Head-Down and Helmet-Mounted displays.

Space technology

Qioptiq has now entered its 40th year in the space industry and continues to be a world leader in the design and manufacture of highly specialised optical space components. Qioptiq has an expertise in the manufacture of ultra thin radiation stable glasses for two main applications: "Optical Solar Reflectors" and "Solar Cell Cover glasses" specifically for space satellites.

From the deployment of the first thin glass in 1971 Qioptiq has been at the forefront of development to meet the demanding requirements of Space Qualified products. These products have been used on a number of major satellite programs, including Space Telescope, Mars Exploration Rover Mission, TDRS, Intelsat, Iridium and Globalstar.

For further information visit:
www.qioptiq.com

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FETURA Advanced Zoom

The new apex in zoom optical performance for extreme automated imaging applications

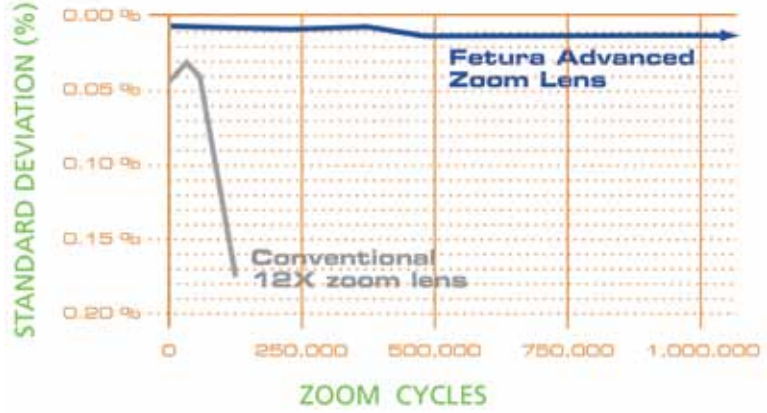
Fetura® represents the performance apex of zoom optical lens technology. Designed to withstand the most extreme rigors of high-throughput automated imaging, Fetura features an innovative electronic linear-rail zoom design which delivers unmatched endurance, speed and precision for inspection and machine vision sectors.

Robust engineering and premium construction guarantee a service life of 1 million zoom cycles... up to 9-times longer than conventional, motorized zoom lenses. It's linear rail design also maintains precision magnification and centration repeatability throughout its extended service life.

Fetura delivers unmatched zoom optical speed covering it's entire 12.5:1 zoom range in under 1-second.

The Fetura® Advanced Zoom is the fastest and most accurate zoom lens on the market.

Equipped with an on-board micro-processor, Fetura can be programmed to 1000 zoom magnification positions. Intelligent optomechanics constantly monitor and adjust lens cell position to eliminate zoom backlash and ensure 0.02% magnification repeatability and centration repeatability within 1 pixel..



Luma X-System

New camera for X-ray technology

X-ray diagnostics can provide detailed images and video sequences from inside the body. Qioptiq is the world's leading supplier of imaging systems in the field of fluoroscopy. The new Luma X-System features an extremely flat design, thanks to improved system components.

The Luma X-System is the heart of a new X-ray detector, and consists of an extremely compact-design lens, the LumaGon, and a flat X-ray camera, the LumaCam. Its modern, 1 megapixel CCD sensor replaces a predecessor that cost almost twice as much. The LumaCam is the first X-ray camera in the world equipped with a powerful GigE Vision interface.

With this new development, Qioptiq has managed to add yet another highlight to what was already the world's largest range of products.

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Two lasers in one

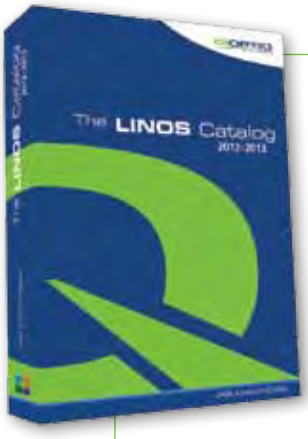
iFLEX-Gemini

See Live Demo! BOOTH 1515

our compact, powerful, dual-channel laser source is now available in a range of different wavelength pairs including, for example, 488/640nm and 405/515nm, ideal for fluorescence, spectroscopy and metrology applications.

Gemini is a compact and cost-effective alternative to setting up and aligning two separate lasers. It offers improved precision and reliability, with its truly repeatable collinear beams and individual wavelength control so that they may be fired independently or simultaneously. The built-in kineFLEX™ fiber delivery system ensures excellent beam pointing stability and co-linearity without cross talk interference between wavelengths.

See Qioptiq's Gemini 'two lasers in one' on display at BIOS Booth 8503 and Photonics West Booth 1515 or contact sales@qpl.qioptiq.com for more information.



The NEW 2012 LINOS catalog

Available now!

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For our customers who prefer the German language edition: The new Catalog will be available in May 2012.

Compact multi-wavelength laser system

iFLEX-Hydra and kineFLEX-Hydra

- Single-mode, polarization-maintaining fiber array
- Precise beam delivery
- Small footprint

Qioptiq's iFLEX-Hydra system is a complete, high reliability multi-laser system with spatially separated output beams. It offers equipment manufacturers a more robust, reliable and compact alternative to traditional bulky exposed-beam assemblies.

iFLEX-Hydra is the multi-wavelength laser system with multiple output channels providing spatially separated beams from a single compact box.

kineFLEX-Hydra is an elegantly-packaged, compact multiple-channel fiber array. It uses singlemode, polarization-maintaining fibers where the polarization axis of each fiber is actively aligned to achieve the customer's requirements, in a closed system that provides very high precision, repeatability and reliability.

See Qioptiq's Hydra system on display for the first time in the US at BIOS Booth 8503 and Photonics West Booth 1515, or contact sales@qpl.qioptiq.com for more information.

QIOPTIQ Photonics for Innovation

Innovate to New Heights!

Launch your innovation

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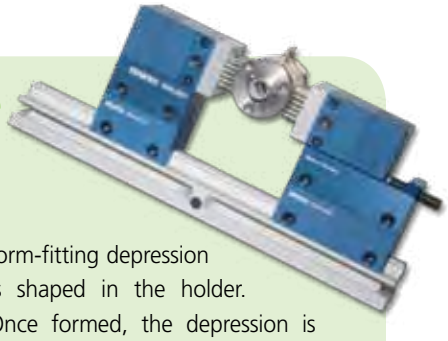
Visit the new "Innovation Launch Pad" at Photonics West and challenge our brightest optical minds with your most perplexing photonic application. Each day, we will draw a winner from the launch pad participants to win a NEW iPad 2!

Innovative retainer systems

Matrix Support and Holder System



The innovative Matrix Support and Holder System is a truly universal retainer system now available from Qioptiq for components of practically any shape. With its M6 connection thread, it is as easy to install on an optical table as it is to combine it with existing support systems. The X-Grip XS, for example, lets you mount components of a variety of diameters securely, all with a single holder. Whether you need a holder for measuring parts in quality assurance or a universal holder for use in the laboratory, the Matrix system is an investment in the future. With a Matrix universal holder, no matter what the next part is shaped like, the right retainer system is already in place.

The principle behind the versatile Matrix support system is to form the support surface directly using the workpiece itself. By gently pressing the component against the light spring pressure of the individually guided pins, a completely form-fitting depression is shaped in the holder. Once formed, the depression is mechanically fixed in place. The result is a stable, part-specific form support. What once entailed elaborate milling or casting is now created within seconds. In contrast to conventional supports, which can only be used with the component they were made to hold, the Matrix system adapts to every workpiece. Any component can be held in place by one single retainer. Perfect form-fitting assures maximum hold with minimum force. This is ideal not only for free-formed parts, but also for workpieces with sensitive surfaces.

Qioptiq offers two sets for different tasks:

The X-Grip XS set clamps the workpiece from two sides. The X-Support XS set features a variable bearing surface and a holding-down device to secure the workpiece.

Dental camera

Liquid lens and autofocus techno-logy: A new generation of dental cameras

Intra-oral cameras are among the standard equipment on today's dental chair units. For dentists, they serve as both communication and marketing instruments. Qioptiq has been developing and manufacturing dental cameras as OEM products for renowned dental equipment manufacturers for more than 15 years. The manual focusing once commonly used has been replaced in the new generation of dental cameras by liquid lenses with autofocus technology. The autofocus solution is extremely rugged and durable, operates unobtrusively within milliseconds and is optimized for the particular conditions of intra-oral use. In short, the dental camera from Qioptiq features a modern and ergonomic design and impressive specifications with respect to watertightness, ease of maintenance, and ruggedness.

Lenses for the world's smallest camera

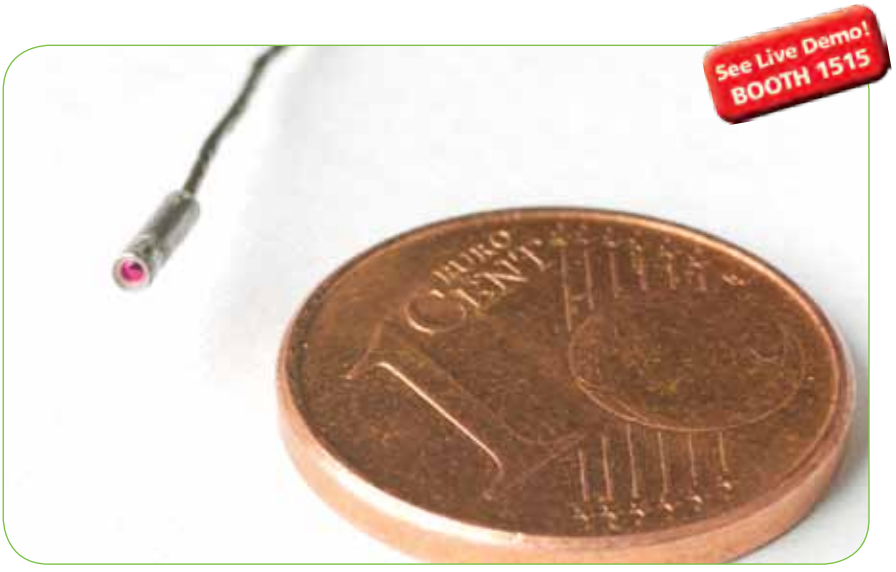
Journey inside the human body

For more than 10 years Qioptiq has been developing and manufacturing high-resolution "chip-on-the-tip" lenses for the use in flexible endoscopes. In cooperation with a long-time partner, Qioptiq has now created and produced a number of different lenses, each with an outer diameter of 1.2 mm, for the world's smallest camera.

When it was introduced at the OPTATEC 2010, the mini-chip lens generated considerable interest among potential customers.

Looking at internal organs

The tiny camera lets doctors take a virtual voyage into the human body to observe living, functioning organs – and sometimes to pinpoint the source of problems, e.g. such instruments can be used to document how blood enters and leaves the heart. For this, an endoscope with a camera travels directly through blood vessels into the heart and supplies a live image. The smallest camera in the world offers a broad array of medical possibilities, from facilitating the diagnostic process to improving precision in surgery. What previously had been hidden from the doctor's searching eye is now vividly revealed.



Unbeatably small and efficient: the smallest camera in the world.

Camera unit

System components	1.2 mm camera head with lens, plus video processing unit
Image sensor	CMOS
Effective pixels	49,280
Resolution	220 H x 224 V
Video signal	NTSC or PAL
System functions	Gain, white balance, automatic gain control, red/blue enhancement, zoom, brightness
Power supply	AC 100-240 V, 50/60 Hz
Aperture angle	100° or 130°
Dimensions: Camera head	
Shape	Round
Outer diameter	1.2 mm
Length	5 mm
Camera cable length	Up to 3 meters
Dimensions: Video processing unit	
Width	300 mm
Height	70 mm
Depth	250 mm

Other areas of application

There is an extensive range of application areas in which the miniature camera can be put to use. Thanks to its ultra-compact design, the system is universally adaptable for use in industry.
Great potential is seen in such areas as machine vision, image processing and inspection systems – up to now, all of these areas offered only limited possibilities in such dimensions. In the medical field, the camera can be integrated directly in flexible or rigid endoscopes.

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Dimensions of the camera.

Higher magnification objective lenses

Integrated beam splitter prism

In high-resolution applications each component is critical in itself. However, the accurate interplay of the components is important for a successful operation. Qioptiq supplies lenses, for line scan applications, that have been prepared for the use of beam splitters for coaxial bright field illumination and offers the appropriate beam splitter module to enable coaxial incident light to be used in these applications.

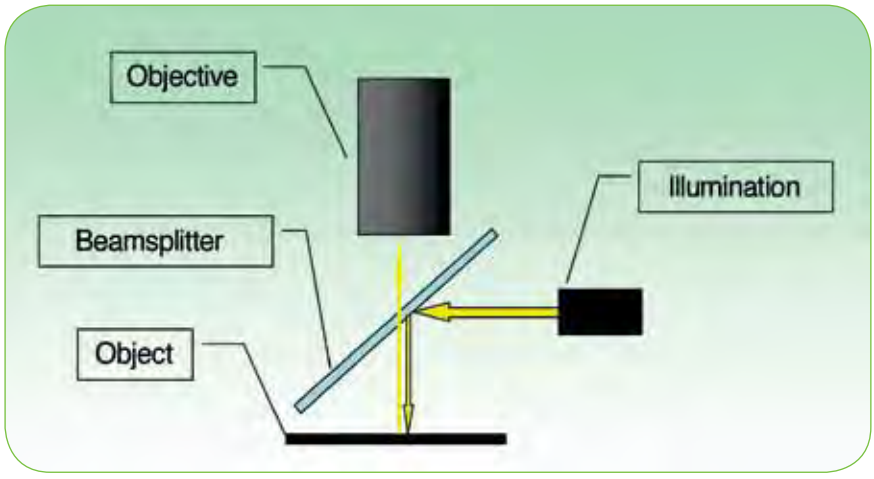

Fig.1: Schematic diagram of the beam path with beam splitter plate for coaxial reflected light illumination.

An image processing system, required to deliver resolutions in the micrometer range, needs components which accurately fit together and fulfil the purpose. Sometimes, however, the available components set extremely narrow limits. Especially for very high-resolution applications with line sensors Qioptiq has dedicated itself to the problem of illumination coupling in the beam path.

Beam splitter prism eliminates astigmatism

It is common practice for macro lenses for sensors up to 2/3" to also have versions with illumination coupling available. For noncritical reproduction scales and resolutions almost every lighting vendor supplies coaxial reflected light modules for positioning between the object and lens (Fig. 1). For high resolutions in the range of 5 µm and below in conjunction with optical enlargements >1 this approach no longer functions satisfactorily. Simulations at Qioptiq have shown that the beam splitter plates installed under 45 degrees to the optical axis introduce a considerable astigmatism which drastically interferes with the optical image. This astigmatism can be completely eliminated if a beam splitter prism is employed instead of the plate and taken into account in the design of the lens. However, for the image beam path the prism represents a lens with a relatively large centre thickness and endless radii.

Diffraction limited imaging quality achieved again

When diffraction limited inspec.x L lenses are combined with long line sensors the prism leads to considerably poorer reproduction performances, particularly at the edges. Fig. 2 shows a comparison of the MTF curves of the inspec.x L 4/105 3.5x – one without and one with beam splitter. The MTF curves are calculated for white light, a prism with a thickness of 12 mm and an image height of 33 mm and show the MTF for 6.25 lp/mm; 12.5 lp/mm; 25 lp/mm and 50 lp/mm

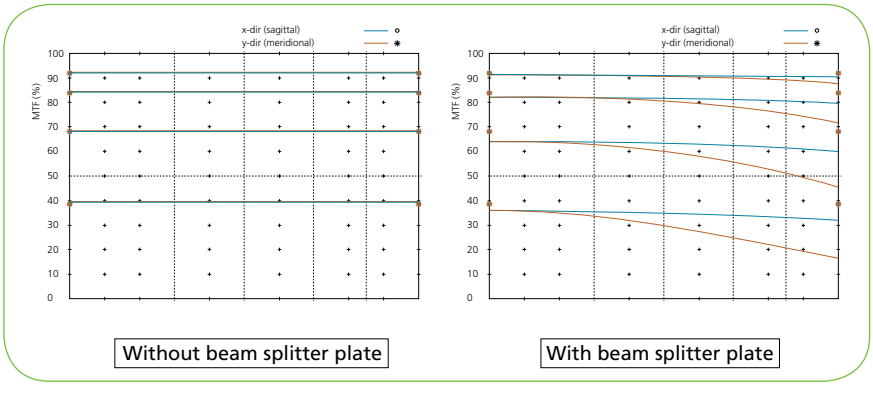

Fig. 2: MTF curve of the inspec.x L 4/105 3.5x lens.

Fig. 4: inspec.x L 4/105 3.5x prism with inspec.x L prism module.

on the image side. At an enlargement of 3.5x this produces a resolution of 175 lp/mm on the object side. Particularly in applications for which the lenses of the inspec.x L series are used this decline in imaging quality is, of course, extremely distressing. Qioptiq has been able to optimize the inspec.x L lenses with 3x, 3.5x and 5x enlargement to such an extent that the diffraction limited imaging quality is achieved once again. Fig. 3 shows the MTF curve for the same parameters including a prism for the inspec.x L 4/105 3.5x prism lens.

Perfectly tuned prism module

Given that the demands on the accuracy of the prism and positioning in the beam path at the required resolutions are considerable, Qioptiq has developed a prism module which is perfectly tuned to inspec.x L lenses. It is simply affixed to the lens and permits azimutal alignment. The module features the customary Qioptiq industrial quality, is optimized for the use of optical fibres and has a universal interface to which standard linear lighting can be attached by means of an adapter. Fig. 4 shows the lens including prism module.

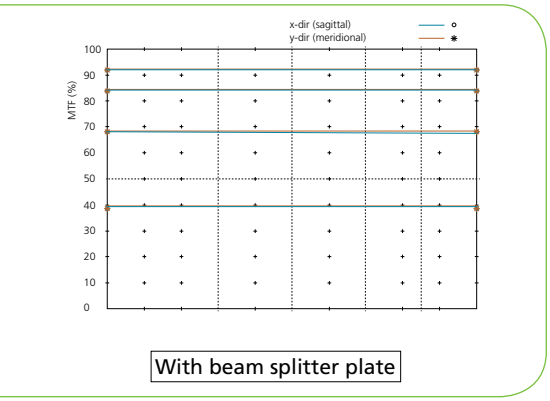

Fig. 3: MTF curve of the lens inspec.x L 4/105 3.5x prism.

Resolutions in microscope regions

The first applications at customers' premises produced outstanding test results – both in the resolution quality of the complete system and simple handling of this example of precision optics made in Germany.
Fig. 5 shows the image of a USAF test chart using a Dalsa Piranha HS 12k in area mode with lighting at 430 nm.

Element 6 of Group 7 can still be resolved, which means that 228 lp/mm can be resolved with the system used with a field-of-view of 17.8 mm. Scanning applications can thus be realised which push into resolution ranges which were previously reserved for microscopes.

Conclusion

The combination of inspec.x L lenses with the new prism module enables high-resolution line applications with coaxial bright field illumination with standard lenses for the first time. Due to the inclusion of the beam splitter prism in the optical design of the lenses, a diffraction limited figure with 3x, 3.5x or 5x enlargement for line sensors up to 82 mm in length can be achieved. Despite the simple set-up for the user and robust mechanical design, no compromises have been made with respect to the imaging performance.

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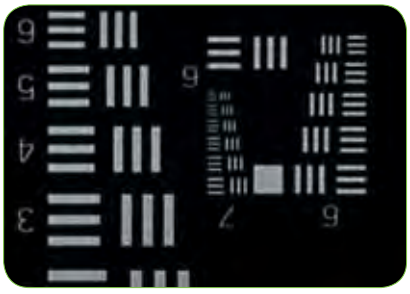

Fig. 5: USAF test chart taken with inspec.x L 4/105 3.5x prism (image kindly provided by Envision, Korea)

Electro-optical control of focus and tilt

Baltic 617: A miniature liquid lens

Liquid lens technology brings a robust, silent, shock resistant and low power solution for fast auto-focus and optical image stabilization in miniature cameras.

Varioptic liquid lenses are now widely used in various systems such as 2D barcode readers, intra-oral cameras, biometrics and industrial cameras. Fast focusing ability, high-quality macro mode, ease of integration and robustness are some of the key advantages of the liquid lens for these demanding applications.

Optical image stabilizer

Due to the trend in high-resolution imaging devices to increase pixel count while maintaining small sensor formats, pixel shrinking leads to degraded light sensitivity. Longer exposure times lead to blurry pictures, especially in hand-held devices; this major issue can only be resolved by an Optical Image Stabilization (OIS) system.

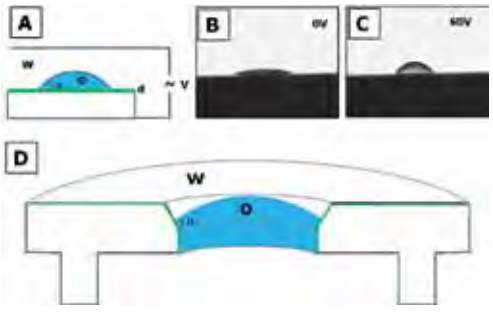

Fig. 1. A: schematic principle of electro-wetting involving a drop of oil (o) having a contact angle α on an insulative coating (green) of thickness d, surrounded by a conducting fluid (w) - B and C: images of the same oil drop on a dielectric coating at 0 and 60V rms (1kHz AC) - D: schematic view of the lower part of a liquid lens, including the dielectric coating (green), the oil drop confined in the conical cavity. (o) and the conducting liquid (w).

With its new Baltic 617 liquid lens, Varioptic offers the first variable focus and variable tilt electro-optical component with no moving parts. This component is well suited to the design of OIS and Auto Focus miniature cameras, as well as any optical setup which can benefit from variable tilt and focus in a single, rugged and fast component. Let's take a closer look at the OIS/AF liquid lens principle and its possible applications.

Liquid lens construction

The liquid lens is composed of two liquids with the same density, one is electrically insulating like oil, and the other one is an electrolyte. They have a refractive index difference to form an optical interface having an optical power depending on the curvature radius of the liquid interface. These two liquids rest on a hydrophobic and dielectric coating. When voltage is applied to the dielectric coating, the wettability of liquids is modified and the curvature of the liquid interface changes (see Fig. 1 – A-B-C). This phenomenon is highly reversible with low hysteresis. In a liquid lens, the oil droplet is spatially confined in a conical cavity and acts as a lens having a variable focal length, depending on the applied voltage c (see Fig.1-D).
When the same voltage is applied on the whole surface of the dielectric coating, the shape of the liquid interface remains both spherical and centered on the conical cavity symmetry axis. When a non uniform voltage is applied along the dielectric coating, we can obtain a tilted liquid interface shape: this is the key principle of the OIS and AF liquid lens component (see Fig. 2). Practically, the generation of a non uniform voltage along the cone is obtained with a design featuring 4 electrodes and a resistive layer between the electrodes (see Fig. 3).

Baltic 617, whose specifications are detailed in Table 1, is a modular component which can be simply plugged on an existing miniature camera in order to transform a fix focus device into an AF and OIS camera module. It can also be used as a stand-alone programmable lens to fit various optical systems used for imaging, beam deviation, or lighting.

The driving circuitry of the OIS liquid lens is very compact due to the avail-

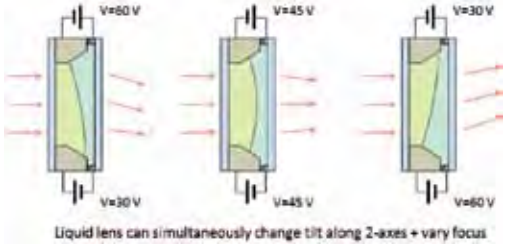

Fig. 2: Principle of the AF+OIS liquid lens.

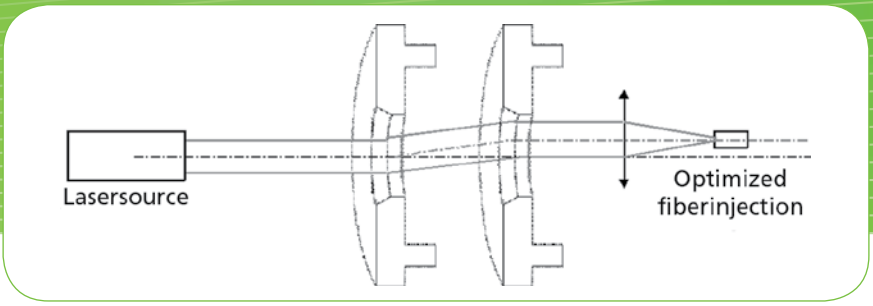

Fig. 4: Optimized fiber injection using 2 OIS liquid lenses and a fiber collimation lens.

Specification	Value	Unit
Clear aperture	2,5	mm
Focus Range	5 bis ∞	cm
Tilt range	±0,6	°
Tilt response time	30	ms
Focus response time	10	ms
WFE – AF mode (for 1.6 mm entrance pupil)	<60	nm
WFE – OIS mode	<50	nm
Full Performance Temperature Range	-10 bis +60	°C
Storage temperature	-40 bis +85	°C
Lifetime	>1 M	Cycles

Table 1. Summary of Baltic 617 specifications.

Fig. 3: Baltic 617 liquid lens with 4 electrodes.

ability of a customized driver chip from Maxim Integrated Products. The autofocus adjustment of the camera module can be obtained with a closed loop command of the optical power of the liquid lens from an estimation of the sharpness of the image by the image processor. The principle of optical image stabilization consists in measuring the instantaneous handshake tilt of the camera module with a two axis gyroscope and generating an opposite tilt with the liquid lens.

Other applications

The OIS liquid lens is mainly dedicated to image stabilization for miniature camera modules. The electrical command of the optical power and of the optical tilt with a miniature component can also be used in a wide range of applications in optics such as optical beam tuner, active spectral filtering or active laser beam injection in optical fiber, see Fig. 4.

Summary

In summary, with no moving parts, the new OIS/AF liquid lens component is silent, robust and easy to integrate. It can combine OIS and smooth AF for picture and video with low electrical consumption.

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Laser beam collimation testing: reliable results in seconds!

New: Shear Plate Interferometer

For fast collimation testing of laser beams under laboratory conditions, Qioptiq offers a new, compact Shear Plate Interferometer that delivers outstanding value for money. Even under unfavorable ambient conditions – whether vibration, dirt, or temperature fluctuations – it provides fast, reliable results with certified, consistent quality.

Fig. 1: Reliable measurement results, outstanding value for money: the new Shear Plate Interferometers.

When expanded laser beams are used in the laboratory, the quality of the laser beam collimation is crucial for the application; in particular when collimated laser light serves as a solid measure. Collimation can be checked using applicable metrology devices, such as a Shack-Hartmann sensor. Shear Plate Interferometers (see Fig. 1) offer an interesting and, moreover, economical alternative.

Principles of Shear Plate Interferometry

Shear Plate Interferometers are based on the principle of superimposing a wave front on itself. The light beam being tested is split into two waves which are shifted laterally to one another, producing the shear. The division and shifting of the wave fronts is a result of the reflectivity on the two surfaces of an extremely flat plate, called the shear plate. The two partial waves interfere in the overlap area (Fig. 2). The original wave front can be derived from the resulting interferogram.

Wedge-shaped shear plates are used to check the collimation of a laser light beam. In the case of an ideally collimated light beam, a smooth wave front is incident on the wedge plate and parallel interference fringes perpendicular to the wedge are formed. This is indicated by a reference band on the observation plane (Fig. 3). With this technique, for example, expansion systems can be adjusted for reproducible collimation [1].

Evaluating the tilt angle

If the expansion system is not aligned properly – it shows either a positive or negative focusing effect – the interference fringes tilt clockwise (negative) or counter-clockwise (positive). This effect can be evaluated quantitatively. Using the tilt angle of the interference fringes, the radius of curvature of the incident wave front, R, can be derived with the following equation:

$$R = \frac{s \cdot d_f}{\lambda \cdot \sin \Phi}$$

Many assembly options

The interference fringes are easy to evaluate visually on the integrated dispersion plate. A reference band is embedded in the plate to detect the tilt angle of the fringes. Qioptiq Shear Plate Interferometers are available in three different models, each optimized for a different beam-diameter range between 1 mm and 25 mm:

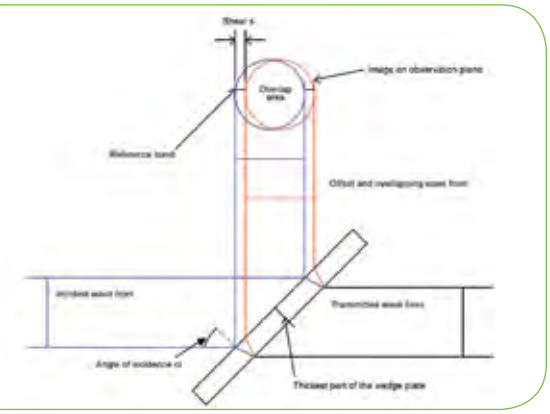

Fig. 2: Operating principle of the Shear Plate Interferometer.

- 1 mm to 3 mm
- 3 mm to 8 mm
- 8 mm to 25 mm

Moreover, these Shear Plate Interferometers are designed with flexible mounting options for trouble-free integration in highly individual optical assemblies. They are compatible out-of-the-box with Qioptiq Rail and Column systems, and adapter plates can be ordered separately for mounting the Shear Plate Interferometers in other systems. Bore holes for versatile mounting options are a standard feature of the interferometer housing.

Mounting compatibilities

- Microbench compatibility: use Mounting Plate 25 with Mounting Holes (G061041000)
- Tube-C system compatibility: use C-Mount/Microbench Adapter (G061659000)

Applications and typical accuracies

Shear Plate Interferometers are primarily used for testing the collimation of laser beams. With a beam diameter of 25 mm, collimation can be determined with a precision of 50 µrad. Because it can determine the radius of curvature of the wave front, the Shear Plate Interferometer can also be used to determine the focal length of weakly focused optical systems, or to determine the radius of curvature of weakly focused convex and concave mirrors in the range above 8 m. For example, using a Shear Plate Interferometer and an expanded 25 mm laser beam, the radius of curvature of a 45 m mirror can be determined with a precision of +/- 3 % by reading off the relevant parameters, given in the equation above.

Other applications and typical accuracies

- Refractive index determination of 10 mm thick plane-parallel plates to +/- 0.001
- Focal length determination of lenses/mirrors to +/- 0.03 %

Tested by MPI in Göttingen

A prototype of the Shear Plate Interferometer (Fig. 1) has already been used at the Max Planck Institute, where it was employed in the Nano-Biophotonics Department for measurement tasks in connection with 4Pi microscopy.

Focus on the Qioptiq Shear Plate Interferometer

- Optimum collimation determination; three models to provide immediate results for beam diameters of 1 mm to 25 mm in Vis-NIR spectra
- Determination of wave front radius of curvature opens up a wide range of application areas
- Adapter plates available for a broad variety of assembly options
- Robust design thanks to common path interferometry and an operating principle without electronic parts

[1] Malacara, D.; Optical Shop Testing. Third Edition Wiley-Interscience Publication New York 2007

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Qioptiq Göttingen

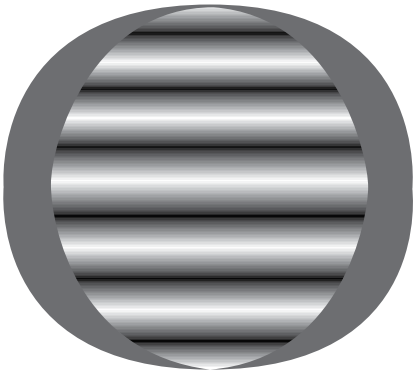
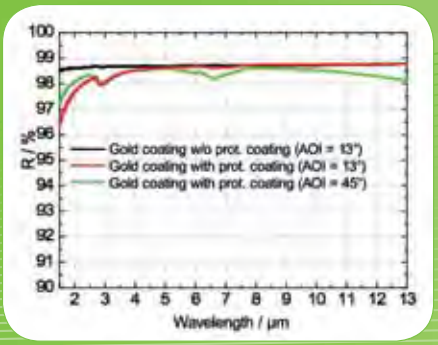


Fig. 3: Interference pattern of a collimated laser beam

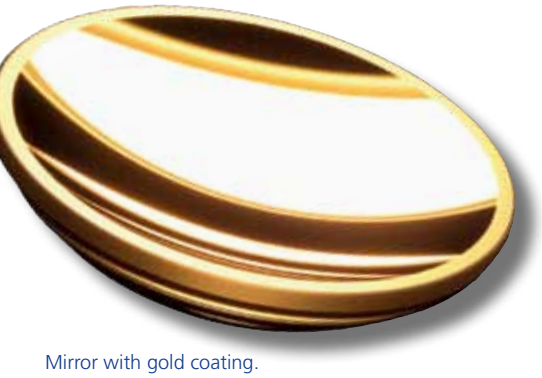


Comparison of gold coating reflectivity values at various angles of incidence.

Excellent product and environmental properties

Gold coating: New technique

Coatings for applications in the near- and mid-infrared spectral ranges have been a core competency at Qioptiq in Göttingen for more than 40 years with a main focus on the gold coating. Now, Qioptiq has developed a new gold coating technique that significantly improves both the product properties and the environmental properties of the gold layer.



Mirror with gold coating.

The exceptional characteristic of gold is its extremely high reflectivity: Ravg >98% above 2 µm, a level not attained by any other material. Gold coatings are found primarily on optical elements used in astronomy, security technology, surveillance and in military applications. With so many different areas of application, gold coatings can be subjected to any of a range of extreme ambient conditions, such as the high humidity at high temperatures found in tropical regions, or extreme temperature fluctuation. Another potential source of wear on the coating's surface is cleaning, which becomes necessary when the element is exposed to dirt. Since gold is naturally a very soft material, such wear rapidly leads to visible damage, or even to destruction or detachment of the coating. This has made it impossible to fully meet the combined requirements of abrasion resistance, high reflectivity, weather resilience and adhesion strength – until now.

New technique developed

Qioptiq has developed a new coating technique that enables full conformity with the stringent environmental stability requirements for gold coatings. One technique for increasing environmental stability is to protect the metal with a thin dielectric coating. To preserve the advantage of high reflectivity provided by a gold coating, however, it was essential to ensure adequate transparency of the dielectric material in the IR range when developing a suitable method for combining the gold layer with the protective dielectric coating. Alongside the production process and good control of the process parameters, this is essential for high reflectivity values.

Environmental stability assured

The new coating developed in the Coating Center at Qioptiq in Göttingen meets the requirements for environmental stability listed in the table on the previous page. This has been demonstrated in accordance with standard test methods, which were applied to various batches of gold coating material on a variety of substrate materials including B270, N-FK5 and diamond-turned and diamond-milled aluminum.

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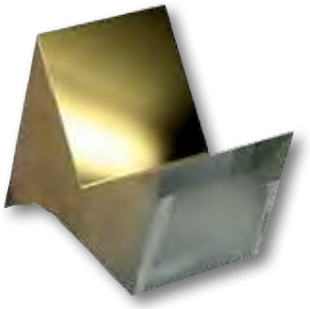

Gold-coated prism system for infrared applications.

Gold coating damaged during environmental testing.

Standard test method

Properties	Verified in accordance with
Abrasion resistance	MIL-M-13508C, 4.4.5 and DIN-ISO 9211-4-01-01
Adhesion strength	MIL-M-13508C, 4.4.6 and DIN-ISO 9211-4-02-01
Thermal shock resistance	MIL-M-13508C, 4.4.4 and DIN-ISO 9022-14-09-1
Solvent and cleaning resistance	MIL-F-48616, 4.6.9.2 and DIN-ISO 9211-3-12-3
Water solubility	MIL-F-48616, 4.6.10.3 and DIN-ISO 9022-4-04-02
Damp heat	MIL-C-48497, 4.4.6 and DIN-ISO 9022-12-07-1

Environmental properties of the new gold coating from Qioptiq.

LED cold light source: CLS-LED USB

External control using “e-Light”

The high-performance LED cold light sources in the CLS-LED series of Qioptiq present an economical and energy-saving alternative to conventional light sources for virtually all of the most common applications. An LED cold light source converts far more energy into visible light than a halogen cold light source can, and yet has a service life of approximately 50,000.

Fig.1: CLS-LED USB with USB interface and function control port.

The light output of the new CLS-LED USB light source can be adjusted quickly and directly using the brightness controller on the front panel. Another option is external control: with a PC connected to the USB port (Fig. 1), the power level can be adjusted through the “e-Light” program that is included in the delivery of the CLS-LED USB (Fig. 2). Up to four different output settings can be stored per light source – for as many as 255 light sources – and then loaded again the next time the source is put into operation. This makes it easy to ensure reproducible conditions for every use. The light source can also be operated in flash mode. When using this mode, the pulse duration, the switch-on delay following the start pulse and the quantity of repeat sequences can be adjusted.

Another feature of this light source is its additional function control port (Fig.1). An external device can be connected to this port, for example, to set the brightness using analog voltage (1 V to 10 V) or to set up external trigger pulses for flash operation.

Focus on CLS-LED USB:

- USB interface and function control port for external brightness control and flash control
- Manual brightness setting with memory function
- Operating software included
- Storage of up to 4 output adjustment settings for each light source
- Noiseless and vibration-free thanks to passive cooling system
- Extremely homogenous, flicker-free illumination
- Constant color temperature: typically 5,600 K
- LED service life: approx. 50,000 h (manufacturer’s specification)

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Fig. 2: Easy-to-use software.

Rugged, very resilient and much in demand

Sapphire windows and sapphire domes

A broad transmission range from 200 nm to 5000 nm and highly resilient: Sapphire [Al2O3] features exceptionally high mechanical stability and scratch resistance, a transparency of 180 nm to 5500 nm and low thermal expansion. Thanks to its extreme hardness and excellent heat resistance properties – the melting point is 2040 °C – sapphire is the material of choice for manufacturing components that will be subject to high thermal loads.

Sapphire is used predominantly in defense applications, the healthcare sector and in laser optics. Common applications for this material include protective windows or view ports for vacuum chambers, and IR and UV sensors and wafers (2" to 6"). Thus sapphire components are most frequently encountered in one of two typical designs:

- Plane-parallel plates, also called "windows"
- Domes (Fig. 1)

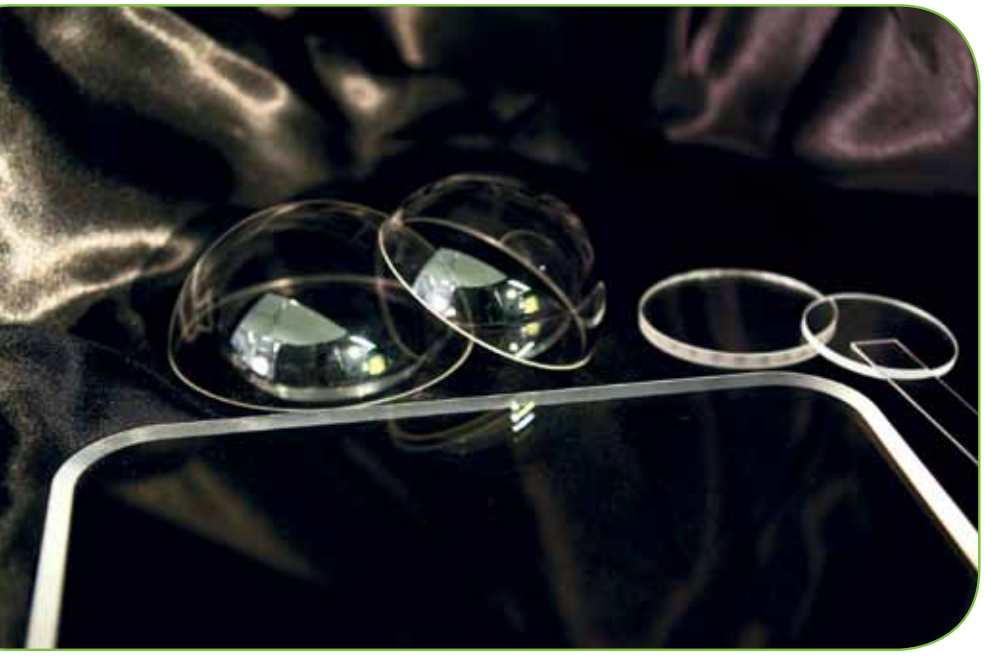

Fig. 1: Typical sapphire components.

Sapphire features a remarkably high degree of hardness: On the Mohs scale of one to ten – where ten is diamond – sapphire has a hardness rating of nine. That is why sapphire processing differs significantly from standard processing techniques used in the optics industry. The polishing process, insofar as it uses diamond-bonded tools, is the only step that is comparable to those used in processing standard materials. The actual polishing process is carried out with abrasive suspensions made of diamond, boron carbide or silicon carbide, using successively smaller grit sizes (Fig. 2).

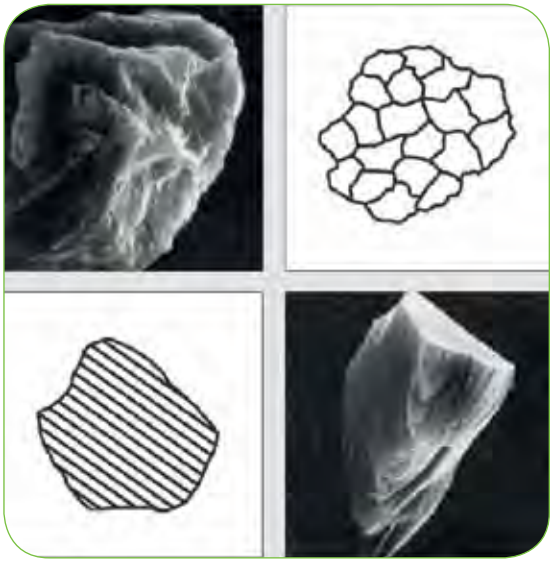

Fig. 2: Characteristics of abrasive materials.

The typical patterns produced when processing domes are caused by the varying processability of the crystallographic planes (Fig. 3). Although ever-smaller particles are used in polishing, the required surface quality usually cannot be attained in this step. The surface quality is refined in a subsequent step, which involves a chemical process based on the following equation: $Al_2O_3 + 2SiO_2 + 2H_2O \rightarrow Al_2Si_2O_7 * 2H_2O$. Fig. 4 summarizes the processing steps.

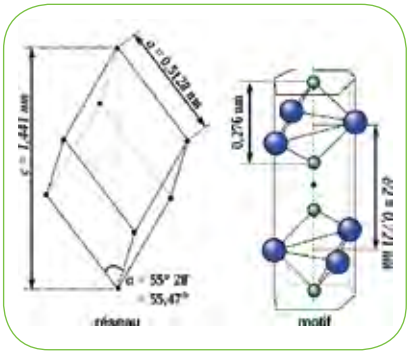

Fig. 3: Sapphire crystal lattice.

The crystal structure of sapphire is multifaceted. The diameters processed can even exceed 225 mm, just depending on requirements. Individual sapphire windows can have a thickness of less than 0.5 mm. LINOS catalog products from Qioptiq include mounted and unmounted sapphire windows with diameters of 12.7 mm to 50.8 mm. Only sapphire of the highest possible optical quality is used in their manufacture. Sapphire windows and domes are distinguished chiefly by low wavefront distortion, to λ/8, and a parallelism better than 5′ in a test range of 85% of the clear aperture.

Customized rectangular sapphire windows can be supplied on request. The minimum and maximum dimensions possible for length x width x thickness are:

- Length: 6 mm to 130 mm
- Width: 6 mm to 20 mm
- Thickness: 1 mm to 10 mm

Focus on standard sapphire windows

- Orientation: (0001) C level
- Parallelism: ≤ 5′
- Choice of mounted or unmounted
- Wave front distortion: λ / 4 or λ / 8

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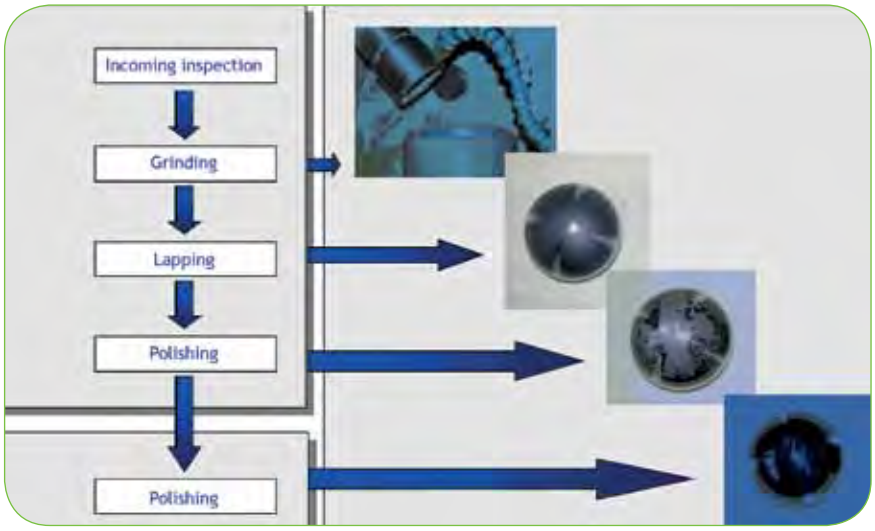

Fig. 4: Steps in sapphire processing.

Materials, designs and manufacturing methods

Lightweight mirrors for space telescopes

Telescopes installed in space probes and satellites open realms of exploration that cannot be reached by Earth-bound instruments. Whether in orbit or traveling through space, they supply information that cannot be detected by telescopes on Earth, which are limited by light attenuation and the filtering effect and turbulence of the Earth's atmosphere. The optics and mirrors in space telescopes have to be specially designed to withstand extreme conditions.

When reducing weight of telescope mirrors – known as "lightweighting" – it is essential to take the mechanical stress into account that has an impact on the mirrors such as when the equipment is launched into space. During operation in space, too, the telescope mirrors must withstand considerable stress in various forms. The SEVIRI radiometer (Spinning Enhanced Visible and Infrared Imager) on board the Meteosat Second Generation satellite, or MSG-1, for example, is spin-stabilized and rotates at some 100 revolutions per minute. This is equal to an applied load of up to 30 m/ s2 (≈ 3 g), which in turn causes significant vibration. The mirrors require a certain degree of stiffness to resist these forces.

Extreme temperature fluctuations can also impose excessive mechanical stress on the mirror material. Aside from the thermally induced changes in length of the mechanical retainer, the expansion properties of the mirror material alone can lead to a change in the distance, Δz, between the primary and secondary mirrors in a telescope.

Such variations in this distance can seriously degrade the imaging quality, as illustrated in Figure 1. This shows an example, created with the WinLens3D optical design software from Qioptiq, of a simulated wavefront diagram of a Cassegrain telescope. A significant change of the peak-to-valley value (PV) and the root mean square (RMS) deviation from the ideal form is discernible.

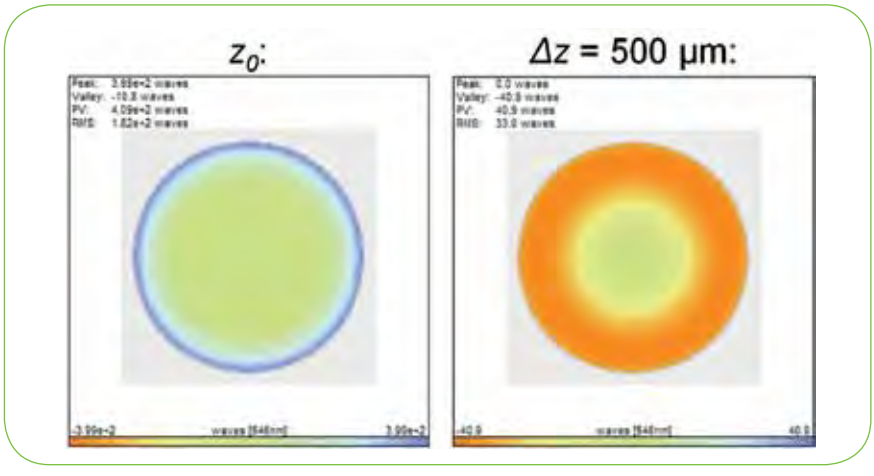

Fig. 1: WinLens3D simulation of the effects of a variation in distance, Δz, of 500 µm between the primary and secondary mirrors in a Cassegrain telescope.

Materials for lightweight mirrors

The materials used in the construction of lightweight mirrors must meet a variety of requirements if they are to withstand the conditions under which they will operate. The ability to construct an optical surface of sufficient precision is essential, while at the same time a low coefficient of thermal expansion (CTE) coupled with a comparatively high fracture toughness is imperative. Ultra-low expansion (ULE) glasses made of silicon and titanium oxides are well suited for this purpose, as are glass ceramics like ZERODUR® [1]. Other materials that are commonly used in such applications include ceramics such as silicon carbide (SiC) and composites such as carbon fiber reinforced silicon carbide (C/SiC) [2]. A wide range of techniques are available for processing these materials. An overview of the methods and designs described in the following is presented in Figure 2.

Monolithic telescope mirrors

Hollow grinding is one of the methods used to create a honeycomb web structure, a design that enables lightweighting in conjunction with mechanical stabilization provided by a structure of solid material on the back of a mirror. This method, however, has considerable disadvantages, because

the microscopic geometry of the tools used in this processing step causes microfissures. The depth of these fissures depends on the diamond grit of the grinding tool. A hollow-grinding tool with an average diamond grit size of 9 µm (D9) for example causes microfissures that penetrate to approximately 30 µm. This compromises the stability of the component and results in stresses, which in turn negatively affect the optical quality of the mirror surfaces. An additional processing step, etching, can eliminate the microfissures. The acid used for etching may be hydrofluoric acid (HF), or an aqueous hydrofluoric acid solution, hydrogen fluoride. When the ground glass surface is treated with this wet etching technique, approximately 0.5 mm to 1 mm of material is ablated. Etching is used for other purposes as well, in addition to the finishing treatment of ground surfaces. For example, the Zeiss company has developed an etching technique that is used in manufacturing delicate stabilizing ribs for lightweight construction elements made of glass and glass ceramic, which due to their low wall thickness would break if manufactured with a hollow-grinding tool. This etching method has already been implemented on materials with a wall thickness of just 3 mm.

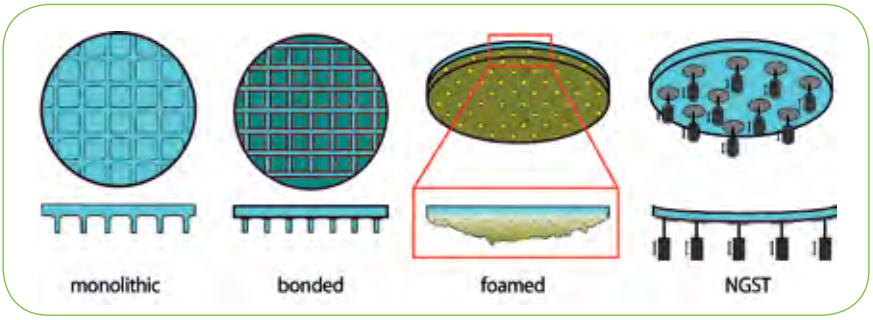

Fig. 2: Various designs and construction methods for implementing lightweight mirrors in space telescopes.

Lightweighting

Another method for producing the stabilizing ribs required for lightweight mirrors employs bonded composite elements [3]. With this method, the web structure is implemented by joining individual plates. Aside from the properties of the materials used in the mirrors and their support structures, properties of the cement or other bonding material are important factors in this technique, including its coefficient of thermal expansion and shrink properties. When the adhesive shrinks during the hardening process, the resulting tractive forces and tensions can lead to deformations of the mirror surface. Such negative effects can be minimized by the use of a monolithic honeycomb structure made of ceramic [4] or a carbon fiber reinforced composite [5]. This entails cementing a stabilizing element between the actual mirror surfaces, made of glass or glass ceramic, and a base plate.

Foamed substrates

The use of foamed silicon-infiltrated silicon carbide (SiSiC) as a substrate is another "sandwich method" for the production of lightweight mirrors. This process begins with the production of a polyurethane mold with a specific porosity. The SiSiC is injected and then bonded and hardened in a vacuum by means of a sintering process. In the next step, the substrate is closed off with a sealing layer of the same material that forms the mirror surface [6].

NGST: The future is here

One ground-breaking development in the area of lightweight mirror construction for use in space exploration is the Next Generation Space Telescope (NGST), also known as the James Webb Space Tele-

scope (JWST). This is an adaptable mirror element designed to be the successor to the Hubble telescope. The basic structural element of the NGST is a thin sheet of borosilicate glass. Pliable as a membrane, this plate is mounted on motorized positioners [7, 8]. The actuators enable dynamic correction of the curvature and contouring accuracy of the glass membrane.

Summary

There is a number of special structural features and environmental conditions that must be taken into consideration when designing and manufacturing lightweight mirrors for use in space telescopes. A variety of materials come into play, including glass, glass-ceramic and ceramic, to meet these complex requirements. Dynamically correctable, adaptive mirrors are among the designs implemented in this field, alongside monolithic mirrors and various composite or sandwich construction methods.

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Reflecting telescope in use: Hubble space telescopes (source: NASA).

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The long-established NANO 250 Series from Qioptiq presents powerful and tunable laser modules in the most compact design available on the market. To keep up with changing market demands and new application technologies for our customers, Qioptiq is constantly advancing its development of this series. In addition to user-friendly operation and the ability to adjust both power and wavelength shift – whether using the PC software or a remote control unit – there is always a demand for better performance and new wavelengths.

For the wavelengths at 405 nm we have increased the power, without increasing the device size, from 130 MW to 160 MW; for 445 nm wavelengths, from 450 MW to 800 MW, and for 532 nm, from 200 MW to 300 MW. The wavelength range has been extended into the IR with 808 nm, 830 nm and 1064 nm, The power at each of these wavelengths is 100 mW.

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- Broad range of use thanks to variable top output levels up to 800 mW and very compact design
- Active, precision-stabilized temperature regulation
- Divergence of less than 0.8 mrad, TEM00
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Operating mode	ACC (active current control PSU)
Modulation Analog/TTL	to 200 kHz (optionally 150 MHz), except NANO 250-532 models*
Noise	<1 %
Temperature regulation	TEC
Laser safety class	IIIB
Dimensions, laser head	70 nm x 30 nm x 31 mm (2.8 in x 1.2 in x 1.2 in)
Weight, laser head	160 g
Storage temperature	-10 °C to 55 °C (14 °F to 131 °F)
Operating temperature	10 °C to 45 °C (50 °F to 113 °F)
Dimensions, AC adapter	60 mm x 90 mm x 30 mm (2.35 in x 3.6 in x 1.2 in)
Length, cable to laser head	0.8 m (31.5 in)**
Modulation input, analog	0 – 5 VDC, optional:. TTL Hi >2.5 V – 5 V
Power supply	95 – 240 VAC, 50 – 60 Hz (sec. 12 VDC)

*NANO 250-532: max. 15 kHz - AOM recommended **Other lengths available on request

Qioptiq Hightech in the Orbit

Glass Melting at Qioptiq

Approximately forty years ago, the first components from what is now Qioptiq Space Technology were launched into space. Today Qioptiq Space Technology (QST) supplies 70% of the Western world's requirements for satellite solar cell cover glasses and OSRs (Optical Solar Reflectors).

Solar cells protected by special cover glasses from Qioptiq.

Components for use on spacecraft must be able to survive the hostile space environment – in particular, harsh ultraviolet light and ionizing radiation (both natural and man-made) which degrade most optical materials, even glass. They are also subject to extremes of temperature (typically -150 to +150 °C) and for satellites in low orbits, the aggressive effects of monatomic oxygen.

Protection in space

Most Earth orbiting satellites rely on photovoltaic solar cells for their power requirements. The cells are sensitive to radiation damage and their efficiency reduces as their temperature increases. The function of solar cell cover glasses is to physically protect the cells from ionizing radiation while transmitting the maximum amount of useful light to the solar cell, protecting the adhesives used from UV damage and radiating as much heat as possible from the solar array.

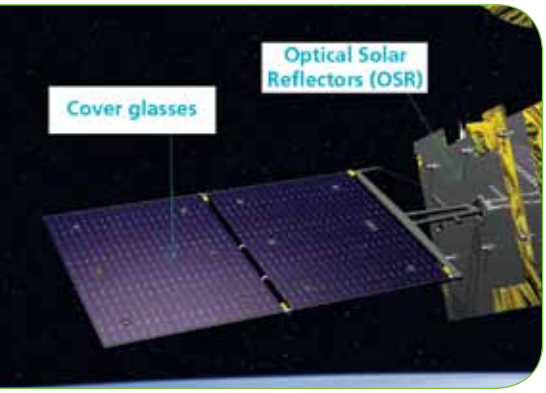
QST has developed a range of specialised glass compositions and advanced vacuum coatings which enable the performance to be optimized for a range of photovoltaic cell technologies and mission requirements.

QST also produces high performance thermal control mirrors (Optical Solar Reflectors - OSRs) which use similar technology to radiate excess heat from the body of the satellite into space with minimal absorption of energy from the sun.

Cover glasses and OSRs are typically 0.075, 0.1 or 0.15mm thick (depending on mission requirements) and may be almost any shape - usually between 10 and 100 cm2 each.

Pilkington glass melter transferred

In order to manufacture these bespoke glass compositions in the thicknesses required, a special type of glass melter is necessary. QST's glass melter was developed by Pilkington (now part of NSG). Following the closure of Pilkington Special Glass Ltd factory in 2007, the melter was acquired by QST and successfully



transferred to a unit adjacent to the existing QST facility in a 15 month project that cost over 1 million Euro.

The melter produces a ribbon of 'microsheet' glass – between 0.05mm and 0.5mm thick. QST processes and coats this to produce finished components: The glass ribbons are first scribed before being accurately machined to the required size and shape. The substrates may also be acid etched to enhance edge strength or even chemically toughened if required.

The substrates then have vacuum deposited coatings applied ranging in complexity from a single layer anti-reflection coating to multilayer band-pass with conductive coating, metallic edge wrap-around and rear surface reflector.
Once final inspection and all quality assurance tests are complete, the components are despatched to spacecraft array manufacturers all around the world.

"Kepler" equipped with Qioptiq glass

There are many, many satellites already flying which utilise components from QST. Examples which have recently been in the news include 'Kepler', the planet hunting satellite and 'Messenger', the first satellite to orbit the planet Mercury. QST cover glasses were also used on one of the Hubble Space Telescope's solar arrays. In addition there are hundreds of satellites in telecommunication systems such as Iridium (66+ satellites), the Astra satellites, Inmarsat (11 satellites) and many more.

Science missions often present unique challenges - 'Messenger', for example needs to survive and generate power in the intense heat and ultraviolet radiation of Mercury's orbit. QST's Development Engineers regularly work with the spacecraft system designers to assist in specifying and optimizing existing designs, or developing new products necessary for this type of unique and challenging mission.

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Defense & Aerospace

Author: D. A. Gray

In the production area.

The quick way to your coated optics

Job coating: Tailored coating solutions

Coatings for applications in the near and mid-infrared spectral range have been a core competency at Qioptiq in Göttingen for more than 40 years. Which coating technique is used in a particular job depends on the individual requirements. For those instances when a coating solution that goes beyond the standard profile of requirements is needed, the Qioptiq design experts at the Coating Center are ready to consult with you and create a coating design that is tailored your specifications.

In addition to an extensive selection of coated catalog optics, Qioptiq offers to implement optical coatings in accordance with your specifications and apply them to substrates that you provide. Our services cover the entire process:

- Incoming inspection
- Substrates cleaned with state-of-the-art ultrasonic techniques or, if necessary, by hand
- Coating design created to your specifications
- Coating applied as specified
- Specs verified using wide range of metrology techniques
- Environmental testing
- Pre-delivery inspection

Coating unit technology

The optical coating systems at Qioptiq use physical vapor deposition techniques, or PVDs, including both thermal evaporation and sputtering techniques. The additional use of an ion or plasma source to enhance the vapor deposition process, moreover, has become a well-established practice at Qioptiq, and improves the optical and mechanical characteristics of the coatings.

Conventional vapor deposition techniques

Conventional coating methods such as resistance-heated evaporation and electron beam evaporation are among the most widely used techniques for coating optical components. In resistance-heated evaporation, the coating material is placed in an electrically conductive metal container called a "boat" (because of its shape) for evaporation. In electron beam evaporation, the energy required for evaporation of the coating material is supplied by a collimated electron beam, which is usually generated by a hot cathode. When the beam reaches the material to be evaporated, the kinetic energy of the electrons is converted to heat. The material to be evaporated is usually in a cooled copper crucible.

During the coating process, the substrates are in a rotating substrate holder above the evaporation source. It is important to rotate the substrates to ensure the homogeneity of the coating over the entire surface of the substrate holder.

The average kinetic energy of the evaporated atoms is relatively low. This results in a low packing density of the coating film, which in turn leads to a greater contamination susceptibility and increased extrinsic losses. This drawback can be offset by an increased substrate temperature, if this is possible with the particular substrates and coating unit. A higher substrate temperature ensures that the coatings will have low absorption and scattering losses, as well as good resistance to environmental conditions.

During the coating process: Material evaporating from a boat.

During the coating process: Plasma source and electron beam evaporator at work.

Plasma-enhanced vapor deposition process

To ensure adequate condensation of the film structure growing on the substrate, the adatoms must be provided with sufficient energy. This can be implemented with the aid of a plasma source. In this case, high-energy ions collide with the growing film, causing its structure to condense with no significant heating of the substrate. Thus the plasma-enhanced process is particularly well suited for temperature-sensitive substrates, or for large optical components that cannot be heated without making the procedure considerably more complicated.

Plasma-enhanced coating: Material evaporates from an electron beam evaporator and the film that grows on the substrate is condensed with a plasma.

Ion-beam sputtering

Unlike plasma-enhanced evaporation, in which ions are used to condense the growing film structure, ion-beam sputtering uses inert gas ions to generate the material vapor by atomizing – or "sputtering" – the target material. The sputtered atoms leave the solid composite with relatively high energy, in comparison to the energy level generated in thermal evaporation. This makes it possible to create structural characteristics similar to those created in plasma-enhanced evaporation.

Qioptiq can create and implement highly sophisticated coating designs using ion-beam sputtering techniques. The characteristics of the coatings produced are significantly better than those resulting from conventional processes. Most importantly, however, the coating systems must be implemented with high accuracy and reproducibility to create coatings that meet elaborate customer specifications.

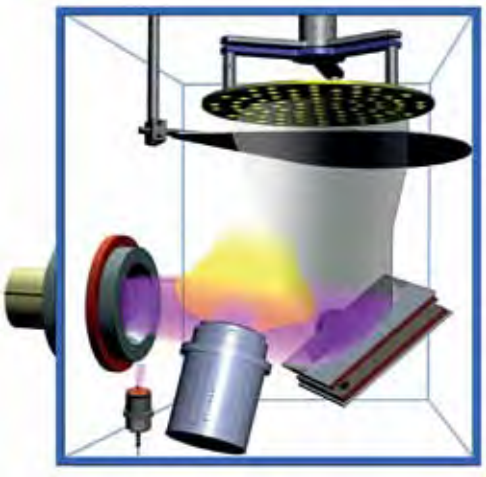
Coating Designs

Qioptiq offers a wide range of coating types to fulfill very specific and individual requirements. The introduction of optical coatings opened up new possibilities in designing complex systems. Coatings on optical components make it possible to split beam paths or combine them, precisely control the polarization of light, filter specific wavelengths or wavelength ranges, minimize troublesome residual reflections, or to increase transmission. Our expertise in coatings extends from the DUV to well into the IR spectral range. The product array includes the following coating types:

- Narrowband and broadband AR coatings
- Dielectric and metal mirror coatings (MR coatings)
- Shortpass and longpass filters (heat protection filter/cold light mirror)
- Beam splitters
- Polarizing filters
- Bandpass filters
- Notch filters (narrowband reflectors)

Measurement technology

Our core competencies include not only the design and application of coatings, but also the verification of coating specifications using all relevant measurement technology. The reflection and transmission of coated and uncoated substrates can be determined in a spectral range from 120 nm to 25 µm, solved for both angle and polarization. Reflection in VIS/



Schematic diagram of the plasma-enhanced IBS process.

NIR on curved surfaces can also be measured, for example to verify the homogeneity of the coating all the way to the edge of a lens.

In addition to photometric measuring instruments, the following measuring stations are also available for verification of specifications:

- White light interferometer to measure surface roughness
- Measuring station for checking surface flatness or transmitted wave front
- Measuring station verifying cleanliness
- Various laser measuring stations that can be refitted as needed
- Cavity ring-down measuring station for measuring low loss of anti-reflective coatings or dielectric mirrors

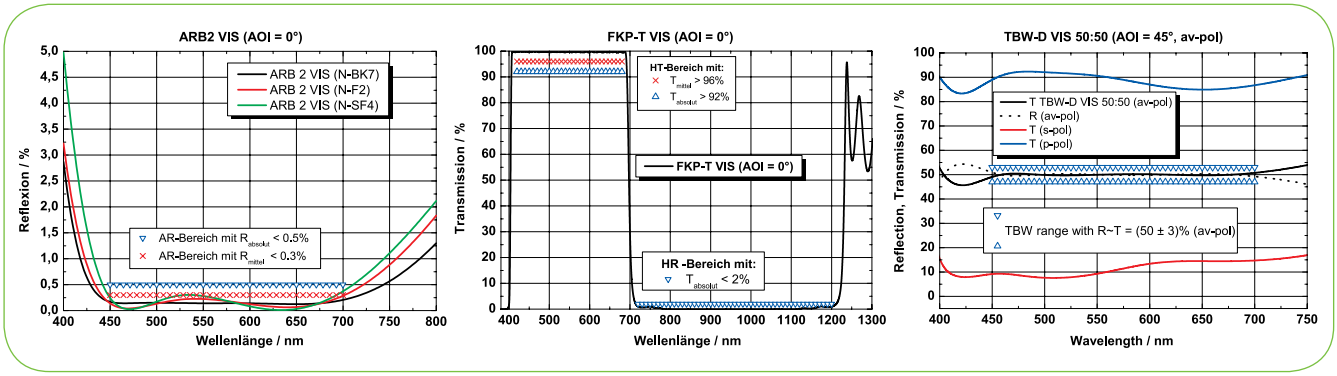
Environmental tests

Our standard coatings are tested and certified using standardized procedures in accordance with DIN/ISO or MIL standards. This guarantees not only the optical performance of Qioptiq coatings, but also the stability of the coated optical components under application conditions and a variety of environmental influences.

We verify the durability of your special coatings by testing the following specifications:

- Abrasion resistance
- Adhesion strength
- Resistance to solvents
- Resistance to deposits from water and salt water
- Stability under environmental conditions (damp heat, cold, dry heat, fluctuating temperature)
- Resistance to laser-induced damage (LIDT)

Contact the design experts in our Coating Center for detailed consultation on customized coatings: sales@qioptiq.de



Examples of coating designs: ARB2 VIS: anti-reflective coating for various substrates; FPK-T VIS: color shortpass filter coating with transmission in the visible wavelength range, and TBW-D: broadband beam-splitter coating.

Exhibitions Qioptiq, January – May 2012

Trade Fair	City	Country	Date	Internet
Security and Policing 2012			31 Jan - 02 Febr	www.adsgroup.org.uk/pages/25413149.asp
International Urban Operations Conference			31 Jan - 02 Febr	www.urban-operations-conference.com/
Medical Design & Manufacturing WEST	Anaheim	USA	14 Febr -16 Febr	www.canontradeshows.com/expo/west12/
DPG TAGUNG	Goettingen	Germany	27 Febr - 02 March	www.dpg-physik.de/veranstaltungen/tagungen/index.html
Focus on Imaging	Birmingham	UK	04 March - 07 March	
MM Live (Micro Mems Nano)	Chicago	USA	07 March - 08 March	www.micromanu.com/x/mm-live-us/mmlive.html
DPG Tagung	Stuttgart	Germany	12 March - 16 March	www.dpg-physik.de/veranstaltungen/tagungen/index.html
Laser World of Photonics China	Shanghai	China	20 March - 22 March	world-of-photonics.net/en/laser-china/start
DPG Tagung	Berlin	Germany	25 March - 30 March	www.dpg-physik.de/veranstaltungen/tagungen/index.html
SME MicroManufacturing Conference			28 March - 29 March	www.sme.org/cgi-bin/get-event.pl?--002080-000007-home--SME-
DAS			16 April - 19 April	www.dsaexhibition.com/
Photonica Moskau	Moskau	RUS	17 April - 20 April	www.biztradeshows.com/trade-events/photonica-moscow.html
Analytica 2012	Munich	Germany	18 April - 20 April	
Photonica Moscau	Moskau	RUS	19 April - 20 April	www.biztradeshows.com/trade-events/photonica-moscow.html
Analytica 2012	Munich	Germany	20 April - 20 April	
DSS			23 April - 27 April	www.dss.mil/
Laser Expo	Yokohama	Japan	25 April - 27 April	www.optronicsjp.com/laser/
CLEO	San Jose, CA	USA	08 May - 10 May	www.cleoconference.org/
AKL	Aachen	Germany	09 May -11 May	www.lasercongress.org/

Editorial staff

We want to cordially thank all of our guest authors, who were so kind as to provide us with their articles, graphs and images. Would you like to contribute an article for a future issue? We look forward to hearing from you! Best regards from Bastian Dzeia, Norbert Henze, Petra Aschenbach, and Thomas Thöniß (l. to r.)

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